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Volume 22, Algorithm Updates for the Fourth SeaWiFS Data Reprocessing

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Chapter 8

The SeaWiFS PAR Product

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Abstract

A new SeaWiFS derived product was developed which provides an estimate for the amount of PAR reaching the ocean surface over a 24 hr period. A description of the algorithm is provided in this chapter, followed by comparisons with *in situ* observations. The *in situ* observations include several years of data covering a wide range of solar illumination conditions. The results indicate good algorithm performance, with RMS differences between satellite-retrieved and observed daily average PAR within a few einsteins per square meters per day.

8.1 INTRODUCTION

The SeaWiFS PAR product is an estimate of daily (i.e., 24 hr averaged) PAR reaching the ocean surface. PAR is defined as the quantum energy flux from the sun in the spectral range of 400–700 nm. It is expressed in einsteins per square meter per day. In the sections that follow, the algorithm is described in detail and comparisons are provided with *in situ* observations from two moored buoys, one at the relatively high latitude of British Columbia, and the other in the equatorial Pacific.

8.2 ALGORITHM DESCRIPTION

The PAR algorithm uses plane-parallel theory and assumes that the effects of clouds and clear atmosphere can be decoupled. The planetary atmosphere is, therefore, modeled as a clear sky atmosphere positioned above a cloud layer. This approach was shown to be valid by Dedieu et al. (1987) and Frouin and Chertock (1992). The great strength of such a decoupled model resides in its simplicity. It is unnecessary to distinguish between clear and cloudy regions within a pixel, and this dismisses the need for assumptions about cloud coverage distribution.

For a solar zenith angle θ_0, the incoming solar irradiance at the top of the atmosphere, $E_0 \cos\theta_0$ is diminished by a factor $t_d t_g/(1-S_a A)$ by the time it enters the cloud–surface system. In these expressions, E_0 is the extraterrestrial solar irradiance at the time of the observation, t_d is the clear sky total (direct plus diffuse) transmittance, t_g is the gaseous transmittance, S_a is the spherical albedo, and A is the cloud–surface system albedo. As the irradiance, $E_0 \cos\theta_0 t_d t_g/(1-S_a A)$, passes through the cloud–surface system, it is further reduced by $(1-A)(1-A_s)^{-1}$. The solar irradiance reaching the ocean surface is then given by

$$E_s \;=\; \frac{E_c(1-A)}{(1-A_s)(1-S_a A)}, \tag{15}$$

where A_s is the albedo of the ocean surface and $E_c = E_0 \cos\theta_0 t_d t_g$ is the solar irradiance that would reach the surface if the cloud–surface system were nonreflecting and nonabsorbing. In clear sky conditions, A reduces to A_s.

To compute E_s, A is expressed as a function of the radiance measured by SeaWiFS in the PAR spectral range (i.e., in bands 1–6, nominal center wavelengths from 412–670 nm). The algorithm works pixel by pixel and proceeds as follows.

First, for each pixel not contaminated by sun glint, the SeaWiFS observed radiance in band i at the top of the atmosphere, $L_t(\lambda_i)$, is transformed into reflectance, $\rho_t(\lambda_i)$, as

$$\rho_t(\lambda_i) \;=\; \frac{\pi L_t(\lambda_i)}{E_0(\lambda_i)\cos\theta_0}, \tag{16}$$